

NUCLEAR GAUGES USED FOR DENSITY OF VARIOUS MATERIALS

1. SCOPE: This method **is used to determine the** describes the determination of in-place density of various materials using the backscatter or direct transmission method. This procedure supplements the **manufacturer's instruction manual** Division of Construction's "Instructional and Manufacturers Operational Manual for Nuclear Gages" by outlining **procedures** requirements relating to for density testing.
2. APPARATUS:
 - 2.1. Nuclear density gauge: **An instrument** A device containing two radioactive sources, combined with density and moisture detectors and other basic components, housed in a single unit for the backscatter method or direct transmission. The devices considered in this method are Troxler Model 3411B, Troxler Model 3430, **Troxler 3440 and Humbolt 5001EZ.**
 - 2.2. **A portable reference block: This block is used to establish standard counts and as a repeatable reference for verifying stability of the gauge. A portable reference stand to calibrate the nuclear gage in the field on the material to be tested.**
 - 2.3. AC charger for office **charging** use and a DC charger for charging from a cigarette lighter **in vehicle** receptacle for emergency field use. **Humbolts do not have chargers.**
 - 2.4. Drill rod with puller: Used with a hammer to **create** punch the hole required for direct transmission measurements **in the case of soils or aggregate bases.**
 - 2.5. Scraper plate: Functions as a guide for the drill rod and for test-site surface preparation.
 - 2.6. 4-lb. hammer - To drive the drill rod.
3. CALIBRATION PROCEDURE (Daily Standard Count):
 - 3.1. Perform all calibration requirements daily, or more frequently if transportation, background, or other conditions necessitate. The importance of obtaining a set of accurate standard counts cannot be over-emphasized. The accuracy of measurements made with this instrument is directly related to the accuracy of the standard counts. **Refer to the manufacturer's instruction manual for calibration procedures.**
 - 3.2. Turn-On/Warm-Up:
 - 3.2.1. Model 3411B: **Place the gauge on the reference block.** Turn the "PWR/TIME" switch to the "SLOW" position, and allow the gauge to warm up for at least 10 minutes before **calibration** use.

- 3.2.2. Model 3430: Place the gauge on the reference block. Press the “ON” switch. The gauge will undergo a 300-second self-test. After the self-test is complete, the gauge is ready for calibration will be ready for use.
- 3.2.3. Model 3440: Place the gauge on the reference block. Press the “ON” switch. The gauge will undergo a 300-second self-test. After the self-test is complete, the gauge is ready for calibration.
- 3.2.4. Humboldt 5001EZ: Place the gauge on reference block. Press “PWR” switch. The gauge will undergo a series of self-test routines. After the self-test is complete, the gauge is ready for calibration.
- 3.3. With all models, the source rod is located on the block Place the gage on the reference stand. With both models, the handle end is located on the end of the stand opposite the metal plate. Ensure the gauge base makes firm contact with the surface of the reference block and is flush against the metal plate stand.
- 3.4. Remove the lock from the trigger, and ensure the handle is indexed in the standard or safe position.
- 3.5. Obtain the standard counts as follows:
- 3.5.1. Model 3411B:
- 3.5.1.1. Press the “SHIFT” key, and while holding it down, press and release the “STANDARD/MEASURE” key.
- 3.5.1.2. Release the “SHIFT” key. For 4 minutes the density count will accumulate. Notice “ERR” message in upper left-hand corner The gage will display “ERR,” as well as the accumulating density count, for a period of four minutes.
- 3.5.2. Model 3430:
- 3.5.2.1. Press the “STD” key. The gauge will display the last standard counts accumulated along with “new std cnt?”
- 3.5.2.2. Press the “ON/YES” key.
- 3.5.2.3. Press the “START” key.
- 3.5.2.4. The count time will start, with the time remaining displayed in seconds, beginning at 240 seconds.
- 3.5.3. Model 3440:
- 3.5.3.1. Press the “STD” key. The gauge will display the last standard counts accumulated along with “new std cnt?”

3.5.3.2. Press the “ON/YES” key.

3.5.3.3. Press the “START” key.

3.5.3.4. The count time will start, with the time remaining displayed in seconds, beginning at 240 seconds.

3.5.4. Humboldt 5001EZ:

3.5.4.1. Press the “STD/STAT” key. The gauge will display the last standard counts accumulated along with date and time.

3.5.4.2. Press the F3.

3.5.4.3. The count time will start. After the density and moisture standard will be stored in the registers.

3.6. After obtaining the standard counts, record the counts in the logbook supplied with the gauge.

3.6.1. Model 3411B:

3.6.1.1. Return the source rod to the safe position before viewing the data.

3.6.1.2. The gauge will display the density standard (DS) count after the completion of the count. To obtain the moisture standard (MS) count, press the “MS” key.

3.6.1.3. View the density standard count again by pressing the “DS” key, if necessary. View the counts anytime by pressing the “DS” and “MS” keys. These counts remain in the gauge until it is turned off.

3.6.2. Model 3430: After the standard count is complete, scroll through the menu to the gage will display the “DS” and “MS.” These counts remain in the gauge until another standard count is taken, regardless of whether or not the gauge is turned off.

3.6.3. Model 3440: After the standard count is complete, scroll through the menu to display the “DS” and “MS”. These counts remain in the gauge until another standard count is taken, regardless of whether or not the gauge is turned off.

3.6.4. Humboldt 5001EZ: After the standard count is complete and there are no errors in the standard count, the display will show the “DS” and “MS”.

3.7. In general, a sudden shift of more than one percent in the density standard count, or two percent in the moisture standard count, as compared to the average of the previous four sets, would indicate some abnormality in gauge operation or procedure. In this case, repeat the calibration procedure. If problems persist, contact the central office radiation safety officer (RSO) gage manufacturer.

4. OPERATING THE GAUGE: Use the manufacturer's instruction manual when operating the Troxler or Humboldt gauges. Note: Time settings for a recorded test shall be Normal (1 minute) or Slow (4 minutes).
- 4.1. Place the gauge on as smooth a surface as possible (concrete, aggregate, or compacted soil). Depress the handle trigger, and move the rod handle to the backscatter position. Be certain that the handle clicks into the slot on the index rod trigger is indexed into the slot in the index rod and not pushed below the slot (with the tip of the source rod resting on, or in, the material being tested). Determine this position by pulling up and down on the handle without depressing the trigger or by noting that the padlock hole in the trigger is fully outside of the handle body.
- 4.2. Density and Moisture Determinations:
- 4.2.1. Model 3411B:
- 4.2.1.1. Set the "PWR/TIME" switch on "NORM (one minute count)," and press the "START" key. Note that "ERR" appears in the display.
- 4.2.1.2. At the end of the "NORM" time period (one minute), "ERR" will disappear. The test is now complete. Return the source rod to the safe position before viewing the data. Read the density count ("DC") and moisture count ("MC") measurement registers by pressing the "DC" and "MC" keys, respectively.
- 4.2.2. Model 3430:
- 4.2.2.1. Press the "TIME" key.
- 4.2.2.2. Press the "up arrow" or the "down arrow" until the gauge displays "1 min."
- 4.2.2.3. Press the "ENTER" key.
- 4.2.2.4. Press the "START" key. The gauge will then accumulate counts for one minute, displaying the count time in seconds. The gauge will display a density, moisture, or count value when the count is complete. Return the source rod to the safe position. View all test data by scrolling through the data with the "up arrow" or the "down arrow" on the keyboard.
- 4.2.3. Model 3440:
- 4.2.3.1. Press the "TIME" key.
- 4.2.3.2. Press the "up arrow" or the "down arrow" until the gauge displays "1 min."

4.2.3.3. Press the “ENTER” key.

4.2.3.4. Press the “START” key. The gauge will then accumulate counts for one minute, displaying the count time in seconds. The gauge will display density, moisture, or count value when the count is complete. Return the source rod to the safe position. View all test data by scrolling through the data with the “up arrow” or the “down arrow” on the keyboard.

4.2.4. Humboldt 5001EZ:

4.2.4.1. Press the “MEAS” key.

4.2.4.2. The gauge will then accumulate counts for one minute. The gauge will display density and moisture when the count is complete. Return the source rod to the safe position.

- 4.3. The A moisture and density backscatter measurement is now complete. If testing soil or aggregate base, another option is a moisture and density direct transmission density measurement obtained by punching a hole using the drill rod, guide, and a hammer. Insert the source rod into the prepared hole to the proper depth. The hole for the source rod should always be at least two inches deeper than the depth of measurement. Proceed as directed by Instruction Manual. Remember to set the “DEPTH” switch to the appropriate depth in Subsection 4.2.1 or Subsection 4.2.2, as appropriate.
- 4.4. The gauge displays computed results in pounds per cubic foot (PCF). The data may now be processed to obtain the desired parameter, provided both the test depth and target density have been entered.
- 4.5. Set the “DEPTH” switch on “BS” (backscatter) and the “MOISTURE CORRECTION” on “+00.” Press the “WD” key, and the value of the wet density will appear in the display. Press the “DD” key, and the value of the dry density will appear. Repeat for “M” (moisture content) and “%M” (percent of moisture). When obtaining the moisture measurement on concrete, this value will be the water equivalency of the hydration of the concrete.
- 4.6. To control the top yellow row of keys press and hold the “SHIFT” key. For instance, for “% of Proctor” press and hold the “SHIFT” key and press the “% PR” key. Control the “% of Proctor” function by the top row of keys and the “SHIFT” key. The calculation performed by the “%PR” key is below. The value “z” is a user-defined value for target density.
- 4.7. The value “z” is a user-defined value for target density. Changing the “z” value (target density): Knowing the correct proctor density for the material that is being tested is critical. Ensure that the proctor density is set in the density gauge. Refer to Model’s Manufacturer Instruction Manual.

4.7.1—Model 3411B

4.7.1.1 The processor will display the value of z for approximately five seconds

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after the last depression of the “SET” key. If desiring to change the value of z, then press and hold the “SET” key while the processor is in the “Display z” mode. The display will change the value of z as long as the “SET” key is pressed. The direction of this change (increase or decrease) is determined by the position of the “MOISTURE CORRECTION +/-” switch.

4.7.1.2 If the “SET” key is pressed for longer than five seconds, the rate of change increases to over ten times the slower rate. This feature facilitates rapid offsets of z by large amounts. The rate of change returns to the slower rate each time the “SET” key is released.

4.7.1.3 After obtaining the desired value of z, use the “%PR” function by pressing the “SHIFT” key and then the “%PR” key.

NOTE 1: — Also, use the “%PR” key to compute the percent of solid density if the “voidless density” of the material is known. The “voidless density” is the density of the material as if no air voids were present. The equation is:

$$\% \text{ of Solid} = 100 \left(\frac{DD}{z} \right)$$

In this case, “z” is the user-preset value. This value is preset by the method described above.

To read or change the value of z, press and hold the “SHIFT” key while momentarily pressing the “SET” key. When the gauge is turned on, z is preset to 124.8 PCF.

4.7.2 — Model 3430

4.7.2.1 Press the “MA/PR” key.

4.7.2.2 Scroll with the “up arrow” or the “down arrow” until the “PR” value is displayed. The gage will display the last density value entered along with the question: “change PR value?”

4.7.2.3 Press the “ON/YES” key. The first digit of the value will be flashing.

4.7.2.4 Use the “up arrow” or the “down arrow” to scroll through the digits (“0-9” and “.”). When the correct value is displayed, press the “ENTER” key. The next digit will then be flashing.

4.7.2.5 Repeat the process for each digit, including the decimal, until the desired value is displayed.

5. TEST SITE:

5.1. Determine test sites in accordance with Kentucky Method (KM) 64-113, *Sampling*

Materials by Random Number Sampling, for acceptance purposes. For control strip qualification or other informational testing, the **Kentucky Transportation Cabinet (KYTC) Department** may select test sites without utilizing KM 64-113.

- 5.2. In order to obtain optimum accuracy from the gauge, perform site preparation. The method for site preparation varies, depending on the surface and the type of test performed.

6. DIRECT TRANSMISSION PROCEDURE (FOR SOILS):

- 6.1. Using the scraper plate supplied with the gauge, carefully scrape the surface to a smooth condition, removing all dried and loose material. If the scraping action dislodges surface material, remove it; fill the voids with fine material, and lightly tamp the surface.
- 6.2. Place the scraper plate in the middle of the site, and drive the drill rod into the soil using a 4-lb. hammer. Placing one foot on the plate will prevent it from slipping or otherwise damaging the site by allowing the drill rod to move from side to side. **Ensure that the rod has been driven 2" deeper than the test depth.** ~~Do not drive the rod into the soil more than two inches further than the depth of measurement.~~
- 6.3. Utilize the drill rod puller for extraction of the drill rod. Place the puller on the drill rod before driving. With one foot remaining on the scraper plate, rotate the drill rod to loosen it, and then remove it up and out of the hole. Ensure no damage to the hole occurs.
- 6.4. Place the gauge over the site so that the source rod aligns with the hole. Depress the trigger, and push the **source rod** handle down to the properly indexed position at the desired depth. With the operator facing the scaler module, pull the gauge toward the operator to seat the source rod against the side of the hole. Perform the test at a 6-in. depth.
 - 6.4.1. ~~For Model 3411B:~~ the depth selection switch is graduated from "BS" (backscatter) through 12 in. Dial in the appropriate depth with the switch. Gauges are calibrated on 2-in. increments only.
 - 6.4.2. Model 3430: press the "DEPTH" key. Select the correct depth with the "up arrow" or the "down arrow." When the correct depth is displayed, press the "START/ENTER" key.
 - 6.4.3. **Model 3440: press the "DEPTH" key. Select the correct depth with the "up arrow" or the "down arrow." When the correct depth is displayed, press the "START/ENTER" key.**
 - 6.4.4. **Humboldt 500EZ: Press the F3 to increase or F4 to decrease the value. When the correct depth is displayed, press the "MEAS" key.**
- 6.5. ~~In most cases, the site preparation is the same as for embankments with the exception that more filler may be necessary for surface voids. Graded sand or other suitable material may be necessary in order to obtain a filled surface.~~

7. BACKSCATTER PROCEDURE (FOR AGGREGATE BASE AND CONCRETE):

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- 7.1. Situations may occur in which it is impossible to drive the drill rod into the material without destroying the surface. In this case, use the backscatter procedure.
- 7.2. Under backscatter conditions, site preparation must be more thorough and all voids filled as closely as possible to the same, or similar, density as the compacted material. The gauge must not rock on its base when seated.
- 7.3. When the source rod is indexed into the backscatter position, be careful not to bypass the **intended index notch** detent and force the source rod tip on, or into, the material.
- 7.4. Soils and aggregate compaction are based on a dry density; concrete compaction is based on a wet density. Record only the wet density measurement on concrete.

7.4.1. Model 3411B: refer to the manufacturer's instruction manual. For the Model 3411B gage, obtain the percent of compaction by use of the "% MA" key. Enter the target densities for concrete in the same manner as the target densities for soils and aggregates (see Subsection 4.7).

7.4.2. Model 3430: refer to the manufacturer's instruction manual. For the Model 3430 gage, obtain the percent of compaction by use of the "MA/PR" key. Enter the target densities for concrete by pressing the "MA/PR" key. Then, scroll to select "MA," and change the value as explained in Subsection 4.7.

7.4.3. Model 3440: refer to the manufacturer's instruction manual.

7.4.4. Humboldt 5001EZ: refer to the manufacturer's instruction manual.

8. REPORTING:

- 8.1. Record the station number and transverse location of each test location.
- 8.2. Report the density results on the applicable *Density Test Report*.

9. PRECAUTIONS:

- 9.1. Ensure all personnel operating nuclear gauges are trained in the principles of nuclear testing and all related safety practices. **Operators shall wear personnel monitoring devices such as badges.**
- 9.2. Ensure all **nuclear gauge users** affected personnel **refer to, and observe, the safety precautions** in the Division of Construction's **Guidance Manual** Instructional and Manufacturer's Operational Manual for Nuclear Gauges.
- 9.3. Perform all tests at least 30 ft. from other radioactive material.
- 9.4. Perform all tests at least two feet from any vertical projections (retaining walls, ditches, etc.) and at least three inches from the pavement edge or joint.

9.5. Keep all personnel without monitoring devices at least 15' from the nuclear gauge.

APPROVED _____
Director
DIVISION OF MATERIALS

DATE 2/4/03 _____

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